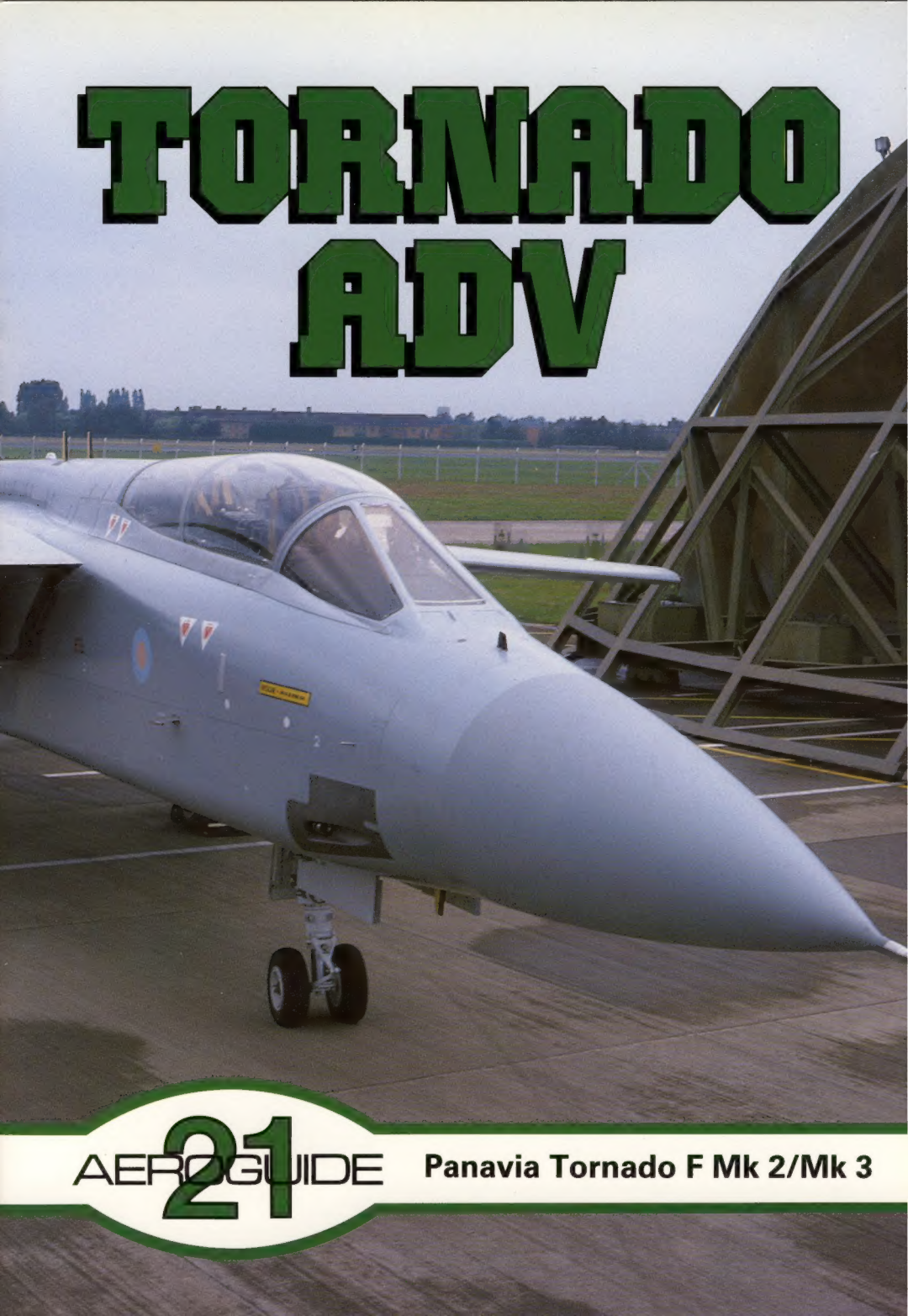
TORNADO ADV



AEROGUIDE 21

Panavia Tornado F Mk 2/Mk 3

AEROGUIDE 21: PANAVIA TORNADO F Mk 2/Mk 3

Published in Great Britain by Linewrights Ltd, PO Box 832, Ongar, Essex CM5 0NH, England

ISBN 0 946958 26 2

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Colour profile and line drawings by Mike Keep
Cover photograph by Joananne Chesneau
Photo processing by Frank Collins

Typesetting by Typesetters (Birmingham) Ltd, Smethwick, West Midlands
Colour reproduction by Columbia Offset (UK) Ltd, London
Monochrome reproduction by M&E Reproductions, North Fambridge, Essex
Printing and binding by Black Bear Press Ltd, Cambridge

ACKNOWLEDGEMENTS

Linewrights acknowledges with grateful thanks the help given by No 29 Squadron, by No 5 Squadron and by No 229 Operational Conversion Unit in the preparation of this book, and in particular the assistance of Flt Lt 'Mac' MacGregor, Flt Lt Tony Paxton, Flt Lt J G Wild and Flt Lt R Burden. Thanks go also to Geoffrey Hill and his staff at British Aerospace's Public Relations Department at Warton, to Del Holyland of the Martin-Baker Aircraft Company, to Dick Ward of Modeldecal, to Peter Simmons of GEC Avionics and to Eric Eatwell at Marconi Defence Systems. Uncredited photos, taken by kind permission of the Officer Commanding RAF Coningsby, are the copyright of the publishers.

Cover photo: A Tornado F Mk 3 of No 29 Squadron poses beside its hardened aircraft shelter (HAS) at Coningsby, July 1987.

Back cover plate: A Tornado F.3 of No 229 OCU showing the 'shadow' No 65 Squadron insignia in arrowhead form on the forward fuselage, mid-1987. This is one of four styles of markings carried by OCU ADVs.

Price £3.95 net (UK only)

TORNADO ADV

Flt Lt Tony Paxton/No 5 Squadron

AERO GUIDE 21

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INTRODUCTION

The Royal Air Force is at the moment involved in one of its most radical re-equipment programmes since World War II, a £15,000 million package that will see the purchase of new training aircraft, a regenerated V/STOL attack force, the continuing upgrading of its medium-range strike and airborne tanker fleets, a modernised airborne early warning element and the renewal of its air defence inventory. Central to this programme is the Tornado: the interdictor/strike (IDS) version of this multi-national aircraft has been established in front-line service for some time now, but increasing numbers of the Tornado air defence variant (ADV) are now also joining the RAF as much-needed replacements for the ageing Phantoms and the positively venerable Lightnings that have hitherto shouldered the responsibility for defending the air space of the United Kingdom.

The realisation of a successful multi-role combat aircraft has been the dream of many but the achievement of few, and while it has very often proven possible to hang a few bombs or rockets beneath the wings of fighter aircraft, evolving a top-class air defence interceptor from a machine originally designed for the attack mission is virtually unheard of. Thus when full-scale development of the Tornado ADV was authorised back in 1976, much scepticism was the order of the day in most 'informed' quarters. It may well be the case that the whole Tornado concept – IDS and ADV – represents, by virtue of its multi-national character, more of a compromise than other military aircraft projects, and it might be argued that, *ergo*, the air defence variant is still further removed from the ideal. However, it is fast becoming obvious – even to the most dyed-in-the-wool cynic – that the aircraft is nothing less than an aeronautical triumph.

The Tornado ADV is more than an airframe: the term 'weapons system' may be a well-worn cliché, but that

it exactly what is under discussion. It is a sophisticated combination of airframe, avionics and weapons, all integrated into an effective package by a highly skilled two-man crew. It represents a quantum leap in capability over the Phantom it is replacing: for example, it has twice the range, or can loiter for twice as long. Its low-speed handling characteristics are already legendary – as one noted aviation writer put it, the Tornado is the slowest fighter in the world – and this, combined with its dramatic thrust-reversing system, means that it can operate from any half-mile long strip of concrete. The AI.24 Foxhunter radar, the subject of some adverse comment in the press (generally by people not in possession of all the facts), links with the Sky Flash missile armament to provide the aircraft with a true 'snap-up/snap-down' capability – differences in altitude of 25,000ft between the Tornado ADV and its prey can be readily coped with – at ranges of up to 25 miles. Though not, according to published figures, possessing the phenomenal climb rate of the Lightning (which few if any aircraft can match even today), the Tornado ADV accelerates better than the Phantom, which is a particular advantage in the Quick-Reaction Alert (QRA) role to which ADVs will eventually be assigned. It has flown unrefuelled across the Atlantic, while early in the trials programme the first prototype flew a simulated combat air patrol (CAP) sortie lasting 4½hrs. With inflight refuelling, the aircraft's stay aloft is limited only by the length of time the liquid oxygen will last.

The first front-line squadron to equip with ADVs has recently (November 1987) been declared operational, and the remaining units will come on stream over the next few years. The aircraft will guard against air attack on land targets in the United Kingdom, on offshore installations such as oil and gas platforms and on friendly shipping up to several hundred miles distant from the British coast, and it will have the responsibility for these tasks well into the twenty-first century. In terms of overall capability it is generally accepted as being second only to the F-14 Tomcat; in terms of cost-effectiveness it wins hands down even over that superlative aircraft.

Below: Posing outside its hardened aircraft shelter (HAS), and with another ADV taking off in the background, this is one of the Tornado F Mk 3s that will be defending British airspace for the next fifteen or twenty years. The use of shelters increases dramatically the chances of aircraft surviving a conventional bombing attack, and they are being introduced countrywide.

DESIGN & DEVELOPMENT

The ADV derivative of the multi-role Tornado is no hastily devised expedient produced to fill the role of defending British airspace. Right from the start of the IDS programme, which got under way in earnest in 1968, a pure fighter version was always a distinct possibility, pending the results of an evaluation of existing US aircraft which might be considered for the job. The latter had been ultimately rejected by 1971, either on grounds of unsuitability (F-15, F-16) or of cost (F-14), and detail design modifications were put in hand with gathering momentum.

Central to the ADV requirements were the four medium-range missiles that would make up the main armament – the US AIM-7 Sparrow, already in RAF service with Phantoms, and subsequently its British adaptation, the BAe Sky Flash. Wing-mounting these weapons was studied, but abandoned because of the drag factor they would impose, and in any case the Tornado's broad, flat belly was a more obvious location. The problem was one of space: the IDS was simply not long enough to accommodate four Sparrows without fouling the undercarriage bays. The solution adopted was the most straightforward one – 'stretching' the forward fuselage by inserting an extra 1ft 9in section immediately behind the cockpit. This was the minimum that could be permitted without upsetting the aircraft's centre of gravity unduly, and the missile layout was still very tight, with the weapons 'staggered' so that they did not interfere with each other whilst avoiding overlap across the corner-mounted main gear bays. The accompanying bonus is that the ADV carries an extra 200 gallons of fuel in an additional tank in the enlarged fuselage.

Further modifications to the structure had to be made up front, principally to accommodate the new airborne intercept (AI) radar system and its associated equipment but also to provide a more refined shape that would reduce drag (and permit improved acceleration) at high speeds. This remodelling added a further 2ft 8in or so of length in front of the cockpit, with the result that the ADV is, in total, 4ft 5½in longer than the IDS.

Other external changes were less noticeable. First, in order to compensate for the slight increase in CG forward, the shape of the fixed inboard wing gloves had to be revised, and the leading edges have a sharper sweep angle than those of the IDS and extend further forward along the main intake structure. Second, one of the two 27mm Mauser cannon – that on the port side – has been deleted, and the space reorganised to accept an integral, retractable refuelling probe; the IDS, in contrast, features a bolt-on external system on the starboard side. A single gun was felt to be sufficient given the ADV's primary

Left: Two photographs depicting A01 (ZA254), the first prototype Tornado ADV, the upper one taken on the occasion of its official roll-out on 9 August 1979 and the lower at the 1980 Farnborough SBAC Air Show. In the year that has passed between the times the photos were taken, some modifications have been made to the aircraft. In particular, the fin-top fairing has been modified and the VOR/ILS antennas immediately below have been relocated; these items would be further altered for production aircraft. *Mike Gething/Richard L Ward*
Right top: The Tornado ADV was a straight adaptation from the earlier IDS strike variant, an example of which is seen here in TTTE markings. Particularly obvious in this photo is the considerably blunter profile of the nose radome, while the cockpit can also be seen to be further aft relative to the intakes. *British Aerospace*
Right bottom: A01 in flight, displaying its external weapons and 330-gallon drop tanks; it can be seen that the outboard wing hardpoints are not in use. The painting of serial numbers beneath the tailerons was discontinued for operational aircraft, and the shape of the taileron tip was cleaned up. *British Aerospace*

Left: A03 (ZA283) was the third ADV prototype and was finished in low-visibility colours. Note the downward-pointing cine camera housing on the forward fin-tip fairing. *British Aerospace*
Right: A02 (ZA267) was the first ADV to be fitted with RB.199 Mk 104s, necessitating extended tail pipes and a new trailing-edge fin fillet. *British Aerospace*
Below left: ZE154, the first production F Mk 3, on manufacturer's flight tests and in 'clean' configuration. *British Aerospace*
Below right: The same aircraft on the same sortie; note the revised fin fittings. *British Aerospace*

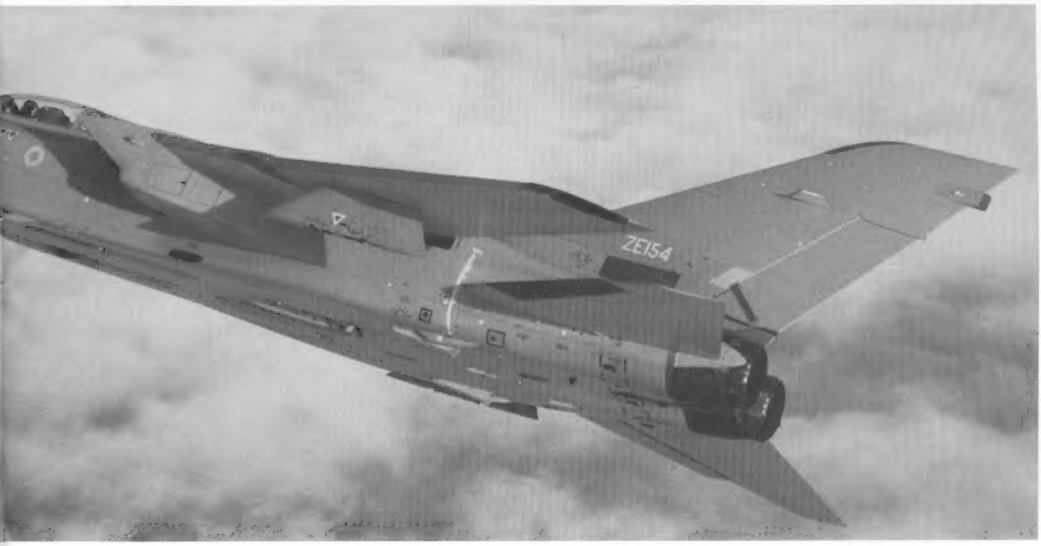
purpose of medium- and short-range engagement of enemy bombers, and the weight saved has prevented a further shift forward of the CG.

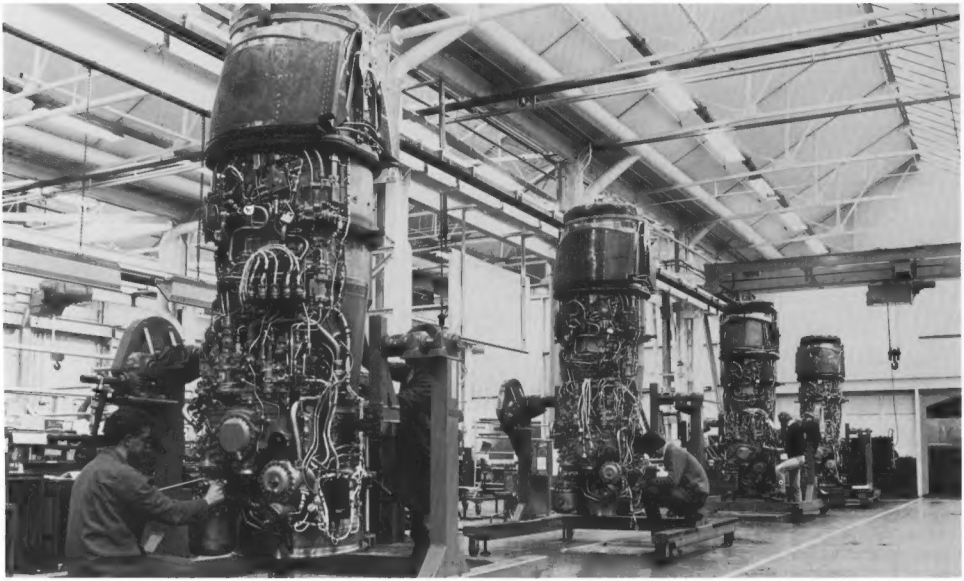
The nineteenth and subsequent production ADVs show a further change in configuration. To provide more 'poke' at high altitudes, the RB.199 turbofan was developed from the Mk 103 installed in early ADVs into the Mk 104, the chief distinguishing feature of which is a tail pipe 1ft 2in longer. This modification can be checked out externally by the amount of grey paintwork visible between the taileron pivot plate and the bare metal of the exhaust nozzle and is the clue to whether an ADV is one of the first-batch aircraft (designated F Mk 2) or a later machine (F Mk 3).

The remaining distinctions between the IDS and ADV are mainly internal. For example, the fighter incorporates such mission-specific equipment as revised cockpit instrumentation, including a head-down display for the pilot, and a new Cossor IFF (identification friend or foe) interrogator. The computer software has of course been completely reprogrammed from that installed in the IDS; moreover, the ADV has a much greater computer capacity than its strike counterpart. A second inertial navigation system (INS), by Ferranti, is fitted, and of course there is a dedicated missile management system (MMS), developed by Smiths Industries/Computer Devices Co. Not yet evident on ADV airframes but certainly part of the original requirement is a visual augmentation system (VAS), similar no doubt to the periscope-like device fitted to some RAF Phantoms to permit long-range 'eyeballing' of intruders by the crew but, according to some reports, mounted in front of the windscreen instead of on the canopy framework. Also not yet installed, but in this case confirmed as 'imminent', is the vital Singer-Kearfott data link system, allowing the secure exchange of information amongst fighter aircraft, airborne early warning and control aircraft and ground stations.

Apart from the new Mk 104 turbofans, the Tornado F.3 demonstrates further improvements over the F.2. Automatic wing sweep (AWS) and an automatic manoeuvre device system (AMDS) are standard in the latest aircraft. The wing sweep angles, selected manually in IDS and F.2 aircraft, offer the minimum 25° setting for low speed and the maximum 67° for high speed, with two intermediate settings at 45° and 58°. Automating wing sweep selection provides the pilot with the optimum setting for the regime in which the aircraft is flying and gives him one less task to worry about. The Mk 104 engines feature a Lucas DECU 500 (digital engine control unit), offering better reliability than the old analogue/mechanical system, all this making sure that the right amount of fuel is delivered to each powerplant at the right time, actuating the exhaust petals to the correct configuration, and constantly monitoring the behaviour of the engines throughout each sortie.

Three ADV prototypes were constructed. The first, serialled ZA254 and designated A01 by the manufacturers, emerged from final assembly in August 1979, first flying some eleven weeks later, on 27 October. It was joined by A02 (ZA267) in early 1980 and by A03 (ZA283) in November of that year. The first production aircraft, ZD899, was a dual-control F Mk 2(T) trainer and was, perversely, preceded into the air by the second 'two-stick' F.2(T), ZD900, which flew in March 1984. The production F.3, featuring the extended tail pipes, appeared in November 1985 as ZE154. Apart from the striking 'hi-viz' paint schemes of A01 and A02, the prototype ADVs differed externally from the production F.2s in a number of minor respects. Most apparently, the IDS-type, fin-mounted antenna fairing was modified for the RAF service machines, the forward extension (used to mount a cine camera in prototype trials) being deleted and the forward-looking radar warning receiver (RWR) gear it might have





Left top: RB.199 powerplants undergoing final assembly at Rolls-Royce's Military Engine Group facility at Bristol. The first, second and fourth engine are Mk 103s, destined for Tornado F.2s; the third in line appears to be a Mk 101 and lacks thrust-reversers. The tail-pipe nozzles are fitted with protective covers to guard against the accidental ingestion of 'foreign objects'. *Rolls-Royce*

Left bottom: One of a well-known series of ADV air-to-air views taken by a BAe photographer from the open loading ramp of a Hercules transport. It depicts a production F Mk 2 flying at a snail's pace, with all its high-lift devices deployed and its tailerons deflected. Notice the spacer between the fuselage side and the inboard wall of the intake, and the curvacious lines of the lower fuselage profile. A full complement of Sky Flash missiles is carried beneath the belly, with Sidewinders on launch rails fitted to the main inboard wing pylons. *British Aerospace*

Right: A Tornado F.3 in the markings of No 229 OCU, the first RAF unit to receive ADVs. *British Aerospace*

housed being relocated in the leading edges of the fixed wing gloves to give improved scanning arcs.

Since it is, in effect, a British national programme, the ADV is having its research and development costs met exclusively from British funds. As with the IDS, however, Aeritalia builds the wings and Messerschmitt-Bölkow-Blohm (MBB) the centre fuselage section, neither of which sub-assemblies is significantly different from those of the strike variant of the Tornado, apart from the special requirements of the underbelly missiles. BAe Warton builds the forward and aft fuselage sections, which is where most of the special features of the ADV are located in any case. The project continues to be managed by Panavia, the parent company for the entire Tornado concept.

The early, 'short-tailed' ADVs, the F Mk 2s, were ordered in August 1981 and began to reach service late in 1984. They were part of the Tornado production Batch 4, assembly and roll-out, as with all ADVs, proceeding concurrently with IDS aircraft at Warton. All had reached squadron service by early 1986, by which time the first F Mk 3s (out of 52 ordered in August 1982 as part of Batch 5) were ready for delivery to the RAF, incorporating the extended tail pipes first trialled on A02, the 'two-stick' second prototype. As of early 1988, the handing over of these aircraft was still in progress. The third (and for the moment final) block of ADVs was ordered in January 1984, numbering 92 aircraft and bringing the total procurement, including the three prototypes, to 165 machines. Of the eighteen Batch 4 aircraft, eight are fitted with dual controls, and eighteen Batch 5 and thirteen from Batch 6 are to be similarly configured. These aircraft, designated F Mk 2(T) and F Mk 3(T), are very modest adaptations of the standard interceptor – hence the style of designation, rather than 'T Mk 4' or something similar – and retain the full operational combat capabilities of the latter. A control column and a basic set of flight instruments are provided in the rear cockpit, but externally it is impossible to distinguish between the two types. For the record, ZD899–904 and 934–935 are the Batch 4 trainers, referred to by BAe as AT001–008. It is doubtful whether the F.2s and F.2(T)s will survive for long in their present form, since they are reportedly due to be sent back to Warton to be modified into F.2As (and presumably F.2A(T)s), incorporating most of the upgraded features of the F.3, except the Mk 104 powerplants.

More ADVs will undoubtedly be built. To start with, there are the 24 aircraft on order by the Royal Saudi Air Force, part of a very large contract also involving the supply of Tornado IDS aircraft and Hawk and PC-9 trainers. These ADVs have been confirmed as part of Batch 7, although at the time of writing it is unclear whether machines allocated to the RAF in Batch 6 will be diverted to meet the Saudi order. The Sultan of Oman's Air Force has eight ADVs on order, plus an option on an additional four, but recent press reports suggest that the delivery of these may be delayed because of falling revenues coming into the Sultanate as a result of the reduction in world oil prices. No further export orders have as yet been confirmed, although it appears that interest had at one time been expressed by other Middle East countries, notably Jordan and Iraq.

STRUCTURE

Derived as it is from an aircraft which is essentially a high-speed, low-level, long-range strike aircraft, the Tornado ADV is, compared with pure interceptors, an immensely strong piece of machinery. The general design, completed before the benefits of carbon-fibre composite materials had been proven, relies on traditional aluminium alloy, with some titanium in heat- or stress-sensitive areas. The fuselage is of the well-tried semi-monocoque, frame and longeron type, and the Italian-made wings are of aluminium alloy, with stiffeners milled integrally with the outer skinning.

The Tornado is a variable-geometry aircraft ('swing wing' in the popular parlance) and hence incorporates a massively strong carry-through wing box structure instead of the more familiar spar arrangement. For maximum strength and lightness it is fabricated from titanium, and assembled by means of a process called electron-beam welding (EBW), so avoiding any potential weak points caused by bolt-holes. Advice and technical assistance for this advanced process was sought from Grumman, who had pioneered the technique and had great experience with it as a result of the F-14 Tomcat programme. Indeed, wing boxes for the IDS Tornados were actually constructed by the US manufacturer until MBB's own facilities were set up in West Germany. To minimise drag, a system of flexible, finger-like seals close the gap along the trailing edge of the wing gloves, the surfaces of those portions of the wings that sweep out of sight being treated with a protective anti-abrasion compound. Further aft, a pneumatic, elasticated seal enables the inboard flaps to slide into the fuselage at maximum sweepback.

The large tailerons form the primary roll control system as well as providing pitch control. They are set low in comparison with the wings, although the latter do not overlap the tailplane at maximum sweep and there is no oversweep 'parking' configuration as there is with the F-14. The tailfin is truly enormous. To ensure that

Above: A No 229 OCU F Mk 2 on display in a hangar at Coningsby. The aircraft is ZD901, one of the first pair of ADVs to be delivered from Warton, both dual-control trainers. This aircraft is 'dressed overall' with anti-FOD covers and 'remove before flight' tags (note the luminous character of the latter), and the nose probe is also protected against damage.
Below: Close-in view of the front cockpit area of the same aircraft. Note IFF antenna in front of windscreen. Cockpit interior colour is medium grey.
Right: A Tornado F.3 of No 29 Squadron is checked out inside its HAS. *GEC Avionics*

stability is maintained at very high speeds and at very high angles of attack (AOA), it would, had the Tornado been designed five years later, probably have been eschewed in favour of twin fins. It is so large that it can accommodate a considerable amount of fuel.

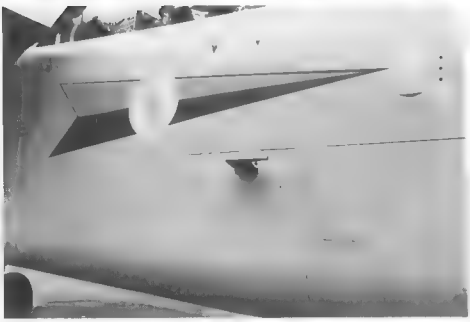
The wings, pivoting by means of duplicated hydraulic motors to ensure precise synchronisation, have variable camber across the entire span, with double-slotted flaps the length of the trailing edges and three-piece slats across the leading edges. Paired spoilers are incorporated in each wing, aiding roll control when deployed differentially or dumping wing lift when used in unison. The Krüger flaps present beneath the glove leading edges on the IDS Tornado are not fitted to the ADV.

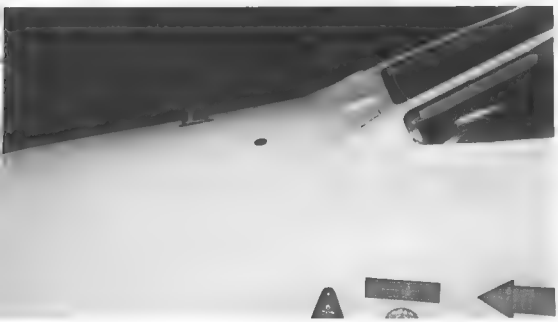
Equally as impressive as the battery of lift-improving devices are the aids to braking. No parachute is fitted, rendered unnecessary by the clamshell-type thrust-reversing 'buckets' which snap out and over the tail-pipe nozzles when the aircraft lands. Two huge air brakes, opening out 50°, are located above the tail pipes on either side of the vertical fin, while to assist braking further the spoilers can be deployed together. Finally, for emergency use, there is a back-up arrester hook for use with runway-mounted wires.

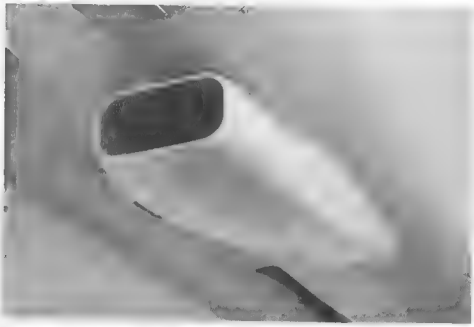
An advanced triplex fly-by-wire (FBW) system, developed by a consortium headed by GEC Avionics, makes piloting the ADV a much more relaxing task than it was with older aircraft. It comprises a command and stability augmentation system (CSAS), which provides automatic stabilisation in gusty conditions, and 'gain scheduling' (optimising performance according to the flying attitude and wing sweep angle selected by the pilot); an autopilot and flight director system (AFDS), which encompasses a terrain-following capability; and a spin and incidence limiting system (SPILS), enabling the pilot to throw the aircraft around in flight with no risk of taking it beyond its design limits or of provoking a spin – in other words providing 'carefree handling'.

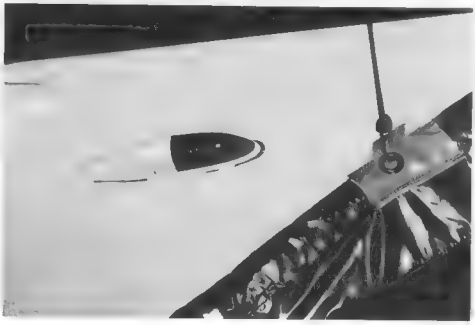
Above: Sleek in appearance in side profile, the ADV looks decidedly chunky from head on, an impression accentuated by the flat undersurfaces of the fuselage and the boxy intakes.
Below: The single 27mm Mauser cannon is mounted low on the starboard side of the fuselage.
Opposite page top: Facilities for rescuing the crew in the event of an emergency are located on the port side of the nose.
Opposite page centre: Detail showing pitot tube (left) and pressure sensor (right).
Opposite page bottom left: Location of flight-refuelling probe, just beneath the windshield on the port side.
Opposite page bottom right: Refuelling probe deployed. On the IDS, this is an external fitting on the starboard side. *British Aerospace*


RESCUE

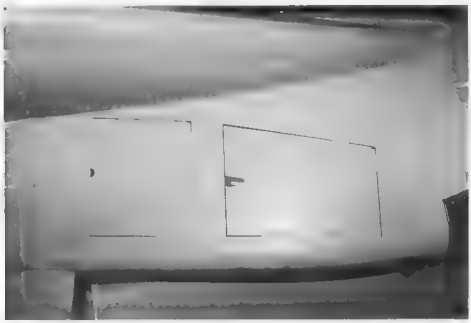


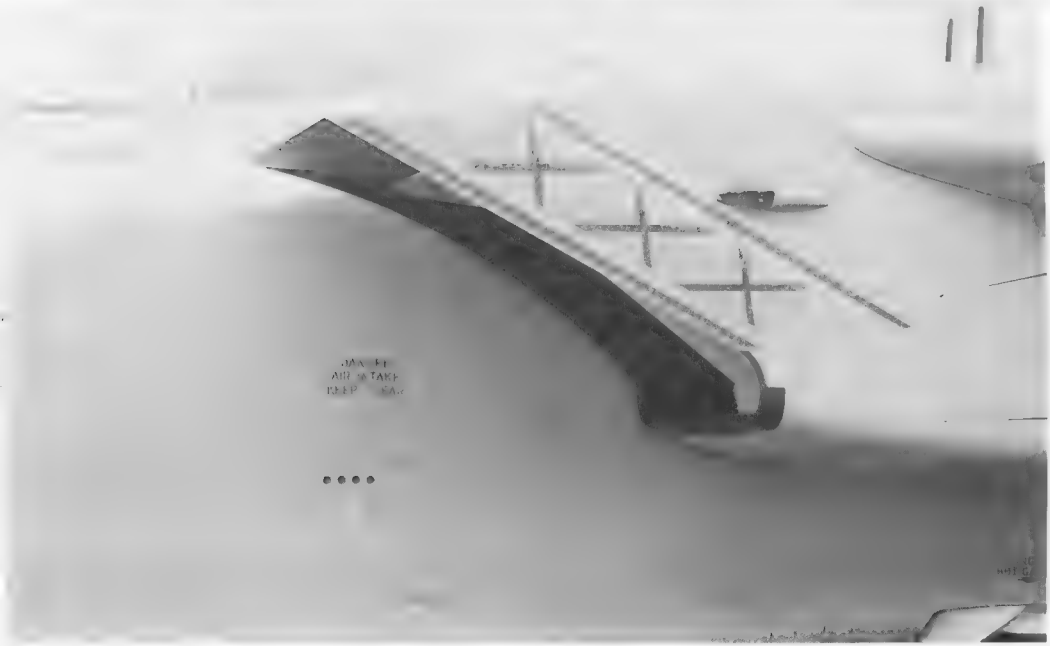


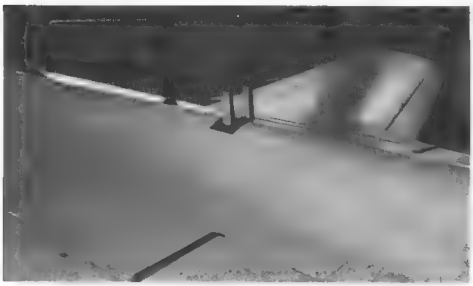


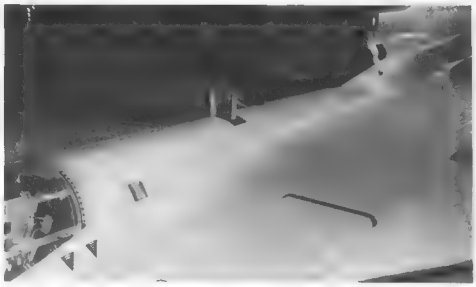


Opposite page top: RWR gear is located in the wing-glove leading edges, behind 'radar-transparent' panels. Bleed air outlet produces a pronounced 'step' on top of the intake.
Opposite page centre left: Detail view of ZD901, showing crew names on canopy sill and wing commander's pennant.
Opposite page centre right: Ram air cooling intake located adjacent to port forward underbelly missile bay.
Opposite page bottom: Starboard intake, showing method of attaching anti-FOD guards, and intake-mounted navigation light. White hatched lines mark walkway areas.
Left: Interior of starboard intake. Note movable ramp at top and fairings over auxiliary air door actuators at left.
Below: Auxiliary intakes, starboard side. These are normally to be seen open only when the aircraft is taxying or taking off.
Bottom: Side view of port intake, F Mk 3. The sharp lips ensure the cleanest possible entry of the air, while the rake forward ensures that this can be maintained at high AOA.

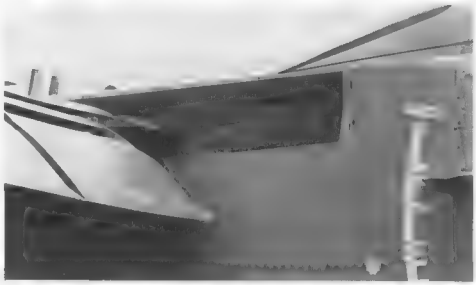








Above: Views over the centre fuselage, showing the twin UHF antennas, buff in colour with black leading edges.
Right: Inflatable seals ensure that the Tornado's wings can sweep back smoothly without leaving any gaps. Stripe at right gives visual read-out of taileron incidence angle.
Below: Disregarding the dorsal spine, the Tornado is flat on top as well as flat underneath, as can be seen in this view.
Opposite page top: Rear aspect of one of the 'short-tailed' F Mk 2s, at Coningsby in June 1985.
Opposite page bottom: The extended tail pipes of the F.3 ADV can be contrasted with the photo above. No 29's tail markings depict an eagle attacking a buzzard are in standard-issue paint colours although some effort was made by the squadron to obtain the brick red and gilt shades used by the unit's aircraft in its early days.

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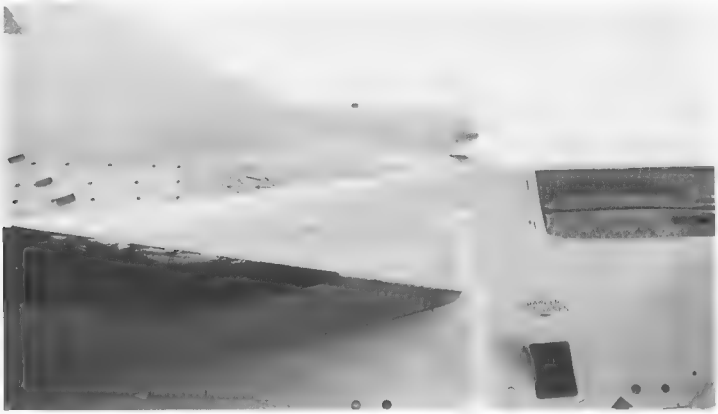
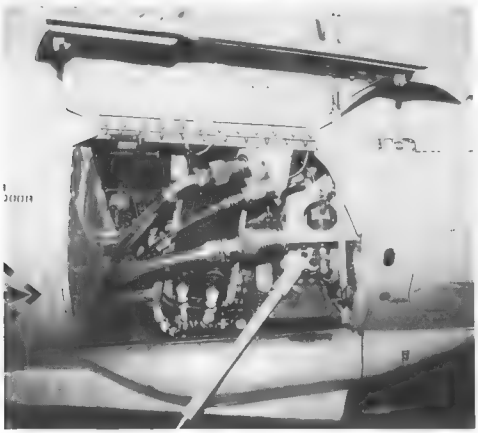
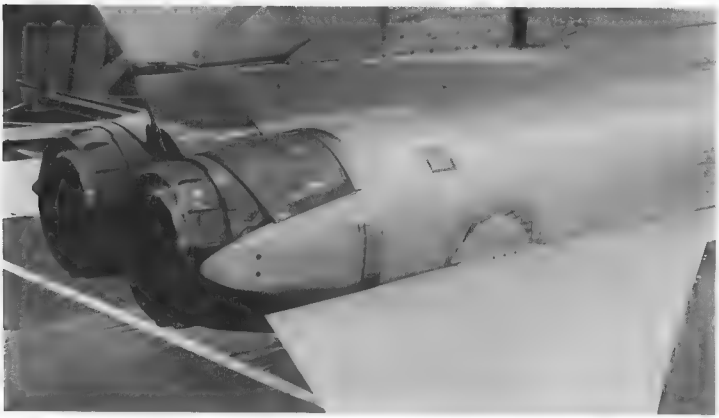
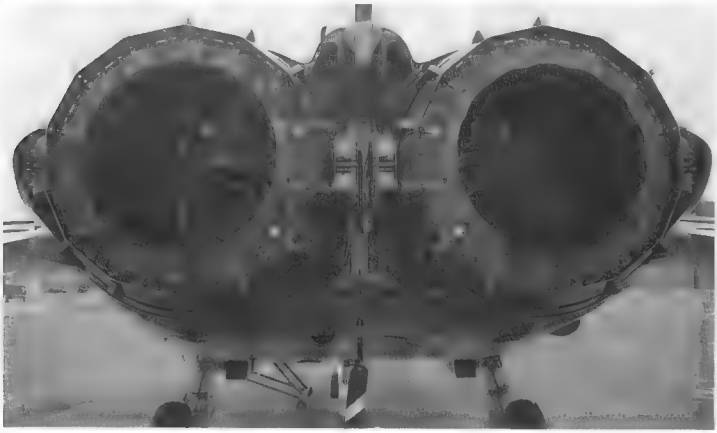
Above left: Tornado F.3 ZE162, showing the No 229 OCU emblem on the fin but the original red and yellow flash beneath the cockpit displaced by the lion passant, fifteen swords and white-backed red chevrons of No 65 Squadron, the 'shadow' unit to which No 229 aircraft are currently assigned. *British Aerospace*
Left: Underwing view of a No 229 OCU/65 Squadron F.3, with leading-edge slats drooped and intakes covered against FOD.
Above right: ZE162 again, with wings at minimum sweep and slats extended. This photo illustrates the 'staggered' layout of the underbelly Sky Flash missiles, and also the meandering nature of the colour demarcation lines nearby. Other points of interest are the matt black wing-tip, taileron leading edge and intake panels, and the medium grey wing root areas showing the portions that disappear into the fuselage when the wings are swept. *British Aerospace*
Right: Another view of ZE162, this time with wings at almost maximum sweep. *British Aerospace*



Opposite page top left: F Mk 2, port side, showing original style of OCU fuselage markings.
Opposite page top right: The ejection seat fitted in the ADV is the Type 10A. This is a training seat; on production examples, the rocket packs are glossy white. Basic seat colouring, here light grey, is currently changing to Dark Sea Grey. *Martin-Baker Aircraft Co*
Opposite page bottom: The Tornado ADV's radome swings open to starboard to reveal the AI.24 Foxhunter radar. The antenna is of the Cassegrain variety, as can be seen. *GEC Avionics*
Left top: The ADV's auxiliary power unit (APU) gives the aircraft a self-start capability; its exhaust outlet is seen to the lower right of this photo. Note icing sensor on intake fairing at base of fin.
Left centre: Rear fuselage details, port side.
Below left: Secondary power system (SPS) access on port lower rear fuselage.
Below right: Detail view of underside of rear fuselage, showing auxiliary outlet on port side. Visible beyond are the Sky Flash launchers. For maintenance, the whole of the rear fuselage swings downwards and outwards as two huge panels; for engine change, the powerplants are simply lowered out of the fuselage by winch. All the vital accessory systems are located on the undersides.







Left top: F Mk 3 jet-pipe nozzles, affording a clear view of the starboard upper thrust reverser in the closed position. The outboard actuators lie behind the triangular-shaped fairing adjacent to the taileron trailing edge. The original concave profile of the Tornado's fin-root fillet can be traced, just above the reverser from this angle; this was later modified to a straighter shape for all Tornados, and extended still further, as here, for the F Mk 3s.

Left centre: View from the port side. Notice the flexible 'fingers' smoothing the taileron pivot plate into the fuselage side.

Left bottom: The twin nozzles feature overlapping 'petals', adjusted by a translating shroud, to give the optimum efficiency whatever the reheat setting. These are the tail pipes of an F Mk 2 (RB.199 Mk 103).

Opposite page top left: Tail details of the ADV, including the shield for the heat exchanger exhaust (left in bare metal) and the row of vortex generators running up the fin (giving the rudder more 'bite').

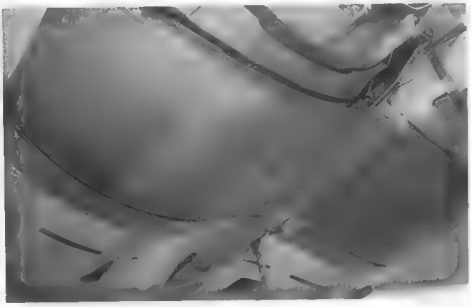
Opposite page top right: The Tornado's slender arrester hook is held ready for use in a neat bay nestling between the engines. It would normally be brought into action only in an emergency.

Opposite page centre: Two photos showing details beneath the tail pipes, that on the right illustrating the lower thrust-reversing 'buckets'.

Opposite page bottom left: Tornado F.2 with tail-pipe FOD guards in place. Panel at base of rudder encloses actuating gear and is left in bare metal finish. Leading edge of rudder is in anti-abrasion finish, matching that used for the 'disappearing' sections of the wings.

Opposite page bottom right: F.3 with tail-pipe FOD covers in position. Note RWR fairing on trailing edge of fin, with tail navigation lamp on the side. 'Kink' immediately above rudder is a fuel dump pipe.

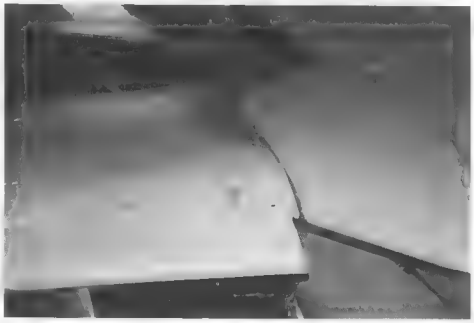

DANGER
HOT GASES

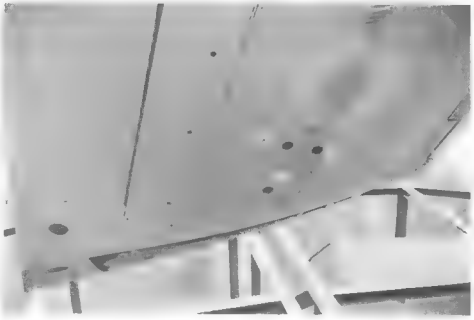


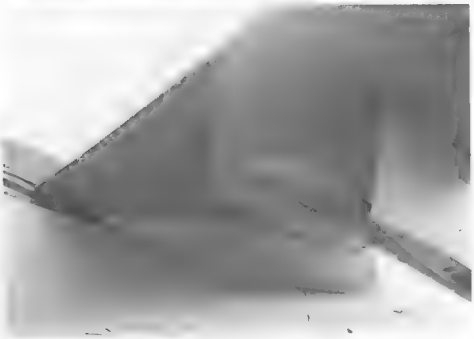

AA

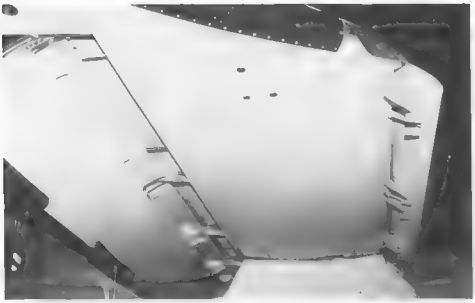

AW

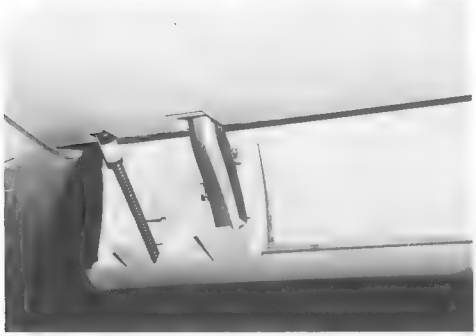
Above: Inboard section of starboard wing, with slats retracted. 'No step' lettering and walkway hatching are white.
Right: Starboard wing glove area, showing inboard slat in deployed position.
Below left: Starboard wing tip detail. Note that the roundel on the upper surfaces of the wings is located well back towards the flap hinge line, clear of the access panels and walkway.
Below right: Port wing-tip undersurfaces, with seepage from integral fuel tank in evidence.
Opposite page: Further wing details, including close-up views of the flap and slat actuator mechanisms. Among the points of interest are the protective covers for the flap trailing edges and the scuffing caused by the glove 'fingers' on the specially treated wing root panelling on one of the aircraft. The Tornado has no 'oversweep' position for the wings, which are normally to be seen extended when the aircraft is parked (permitting the flaps and slats to be in the 'down' position).

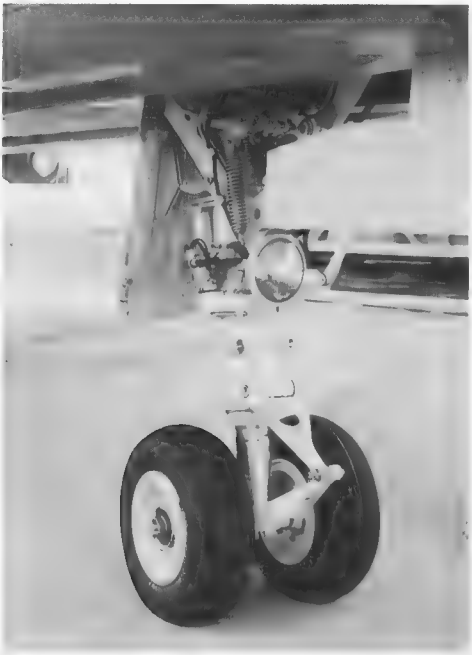


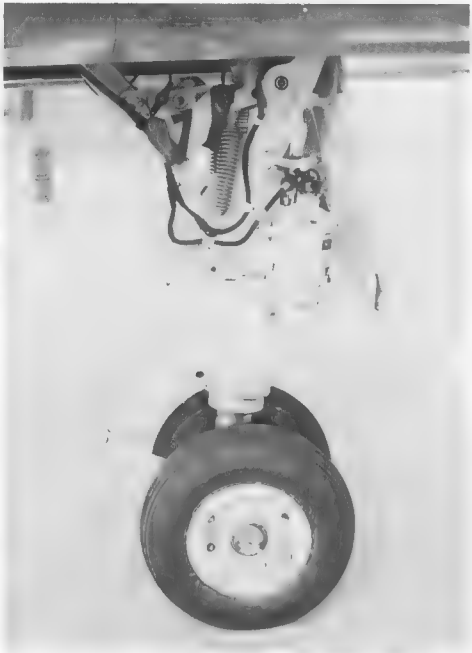


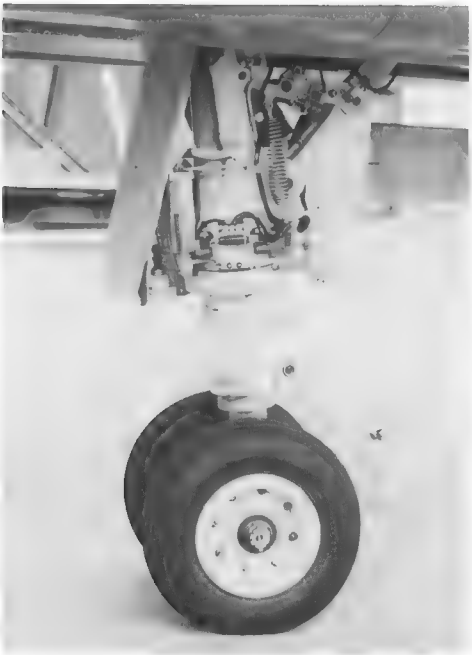




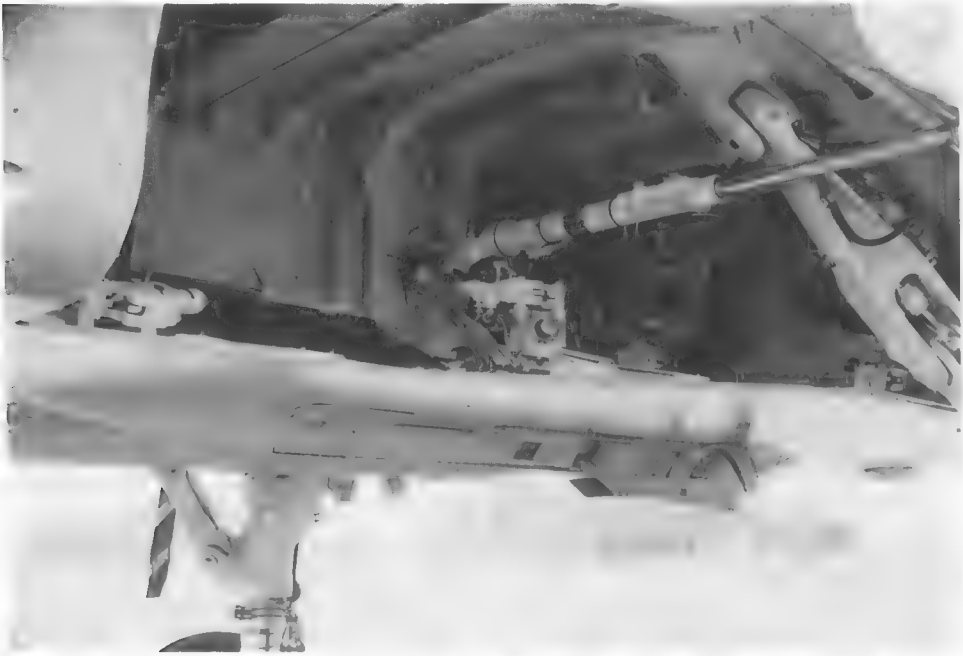


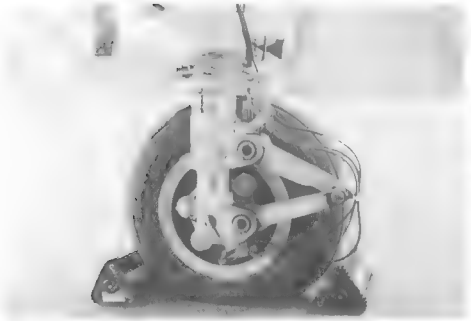


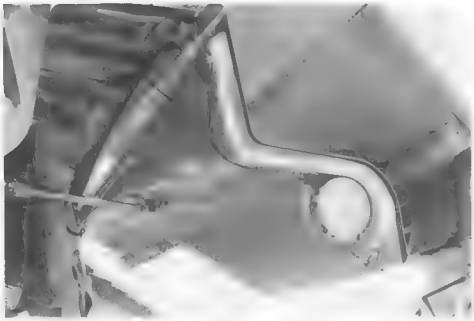


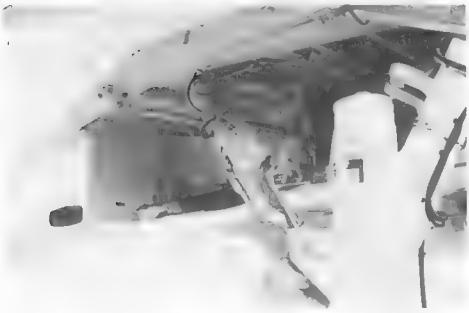


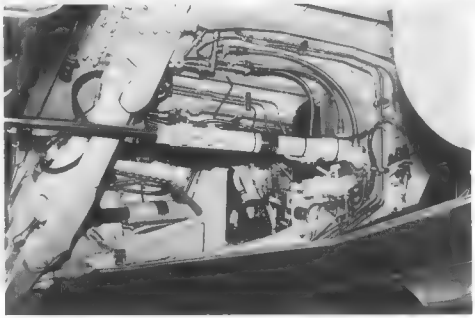
Top: Nose undercarriage gear of the Tornado F Mk 3, identical to that on the F.2 and, apart from some minor modifications affecting the steering system, to that on the IDS version
Left: Nose gear viewed from the starboard side.
Above: View up into the nose wheel bay, looking aft.
Right: Four photos showing the main undercarriage gear, the two upper views depicting the starboard unit and the two lower the port. Dowty Rotol have responsibility for the entire landing gear, with Dunlop producing the wheels, tyres and brakes and Goodyear the anti-skid units. The main gear is, again, virtually identical to that installed in the IDS.
Overleaf: Further angles on the main undercarriage, including details of the voluminous bays.









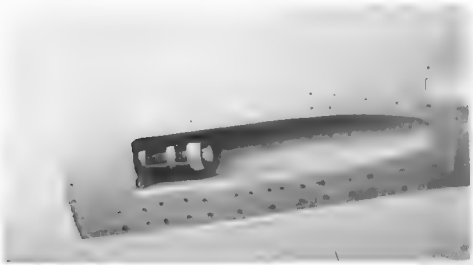


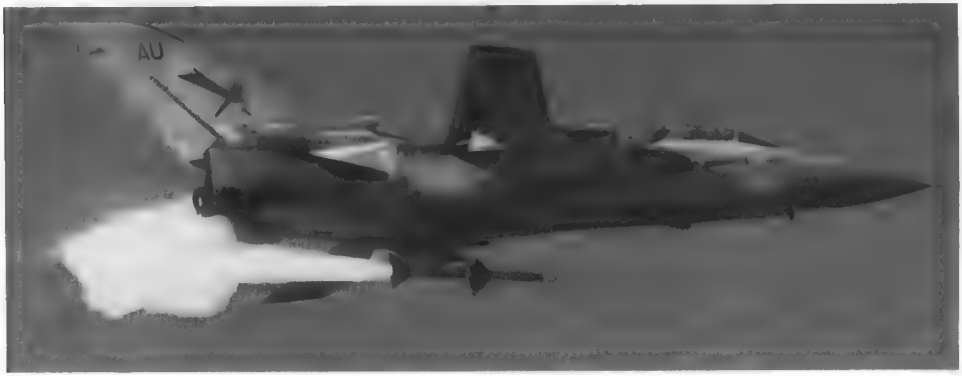
The air defence of Great Britain is a uniquely challenging task. It has to address the prospect of enemy aircraft flying in at any altitude from wave-top height to 60,000ft-plus, almost certainly buzzing with electronic jamming signals and very possibly heading in *en masse*. It also involves 360-degree coverage of the country, since all the approach routes are over the sea. The likelihood is, furthermore, that any enemy attack would be made simultaneously from several directions, and using stand-off weapons. The job, therefore, calls for a very special aeroplane – one that can get out there fast, loiter if necessary and knock down enemy bombers before they can get within lethal range, whether they be cruising in the stratosphere or skimming the sea. The Tornado ADV is designed to cope with all these eventualities, and while it is clearly not in the same category as, say, the F-16, it is also surprising everybody with its additional capabilities in close-combat manoeuvring.

The missile battery, comprising four Sky Flash medium-range and four AIM-9L Sidewinder short-range weapons, has already been referred to. The quartet of medium-range missiles is carried beneath the belly, but there is a difference between the mode of carriage of the forward pair, which is described as 'semi-recessed' and that of the aft pair, described as 'conformal'. The distinction is a fine one, but there are no actual 'troughs' for the rear missiles and it is only the stabiliser fins that are housed inside the main contours of the fuselage. The Sidewinders, attached via launch rails to the main inner wing pylon, may be mounted in pairs or singly, in which latter instance the inboard launchers are those generally used for the purpose. In any event, the carriage of the external fuel tanks (capacity 330 gallons each, although a 495-gallon tank is under development) is not compromised. The outer wing stores hardpoints are redundant on ADVs, at least for the present. The single 27mm Mauser cannon, to starboard in the nose, is identical to those fitted in pairs in the IDS Tornados, and early problems with fusing appear now to have been largely overcome.

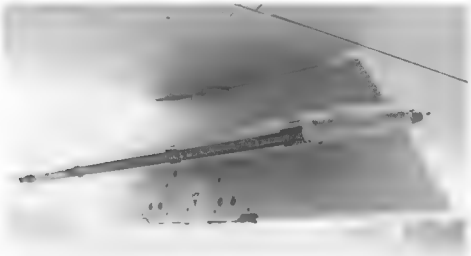
All the missiles in the world are just so much baggage unless there is an effective means of getting them, and first the aircraft that carries them, to the right place to hit the enemy, and it is for this purpose that the advanced AI.24 Foxhunter radar system has been developed by Marconi/GEC Avionics. The equipment has six principal objectives: the long-range (100+ miles) detection of aircraft irrespective of altitude, and their identification; the measurement of the speed, altitude and course of multiple targets (reportedly up to twenty at once); short-range detection and tracking; target illumination (lock-follow) for Sky Flash; pilot controlled (manual) weapons operation for all three armament systems; and navigation (ground mapping). The navigator is provided with two TV tab displays, one of which, in a typical situation, will show synthetic information for target evaluation and the other a plan view detailing the entire range of air activity, friendly and hostile, within the search sector. In this way, an immediate engagement can be assessed concurrently with a picture of the 'general situation'. Foxhunter has five main sub-assemblies: the antenna and scanner, operating

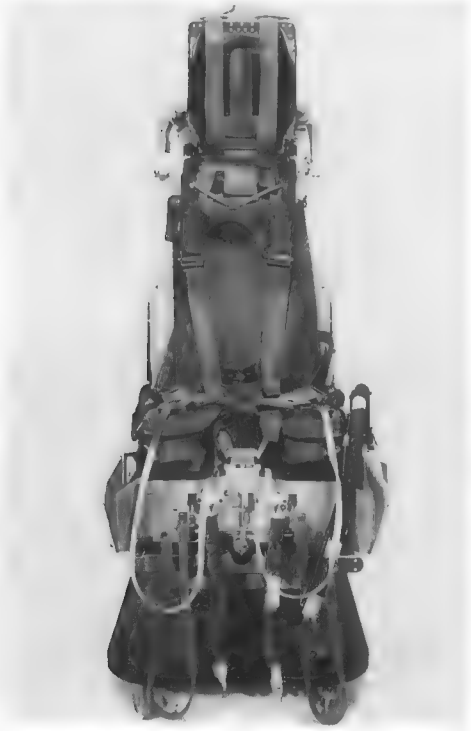
Below left: Muzzle of the single 27mm Mauser cannon fitted to the ADV low in the starboard forward fuselage.
Below right: Detail showing rear Sky Flash missile carriage system, looking forward. Note slot for stabiliser fin.
Bottom: An F Mk 2 launches a Sky Flash from its port rear station. Prior to ignition the missile is forced away from the airframe by means of rams (just visible in this view), ensuring that separation is clean. *British Aerospace*

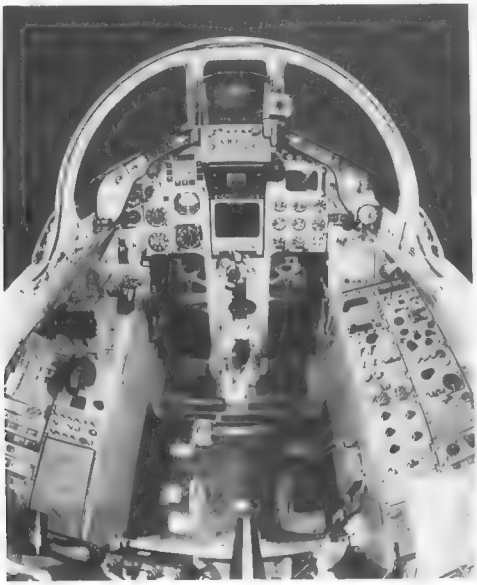


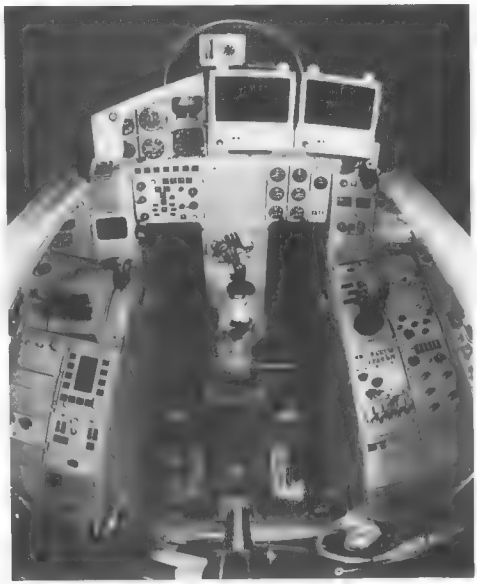


over a range of frequencies and incorporating a continuous-wave illuminator and IFF bands; the transmitter, with an integral CW illuminator for Sky Flash guidance; the receiver; the all-important signal processor, converting the signals received to digital form for display and also identifying and eliminating unwanted signals such as those generated from the ground or produced as a result of enemy electronic countermeasures (ECM); and the radar data processor, converting the signals received into tracks for evaluation by the crew and constantly updating them. Fifteen display formats are available to the navigator; the pilot, for his part, has a single electronic head-down display (EHDD) providing similar information, with the vital symbology projected in front of his eyes on the more important head-up display (HUD).

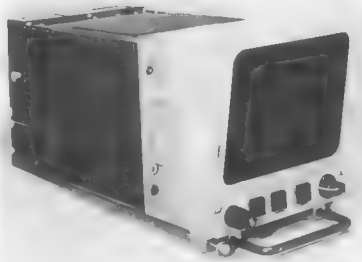


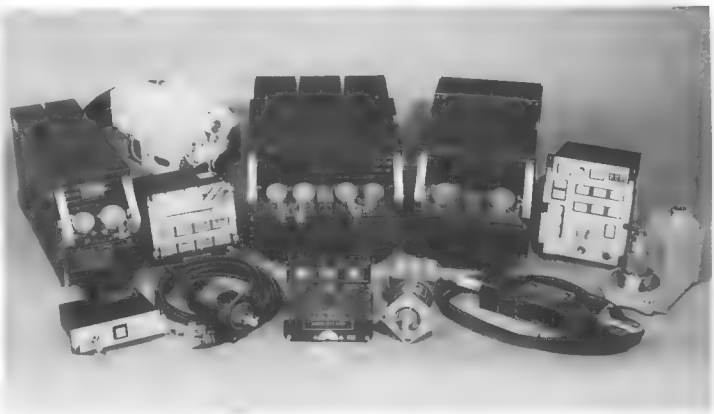






Opposite page top: Sidewinder rails fitted to the inboard wing pylons; an acquisition round is seen in one view.
Opposite page bottom: Two further views of the Type 10A ejection seat. *Martin-Baker Aircraft Co*
Above: Front cockpit of ADV (left) and rear cockpit of ADV trainer (right). The rear cockpit of the standard ADV has an extra display screen in place of the flight instruments at top left and the radar control stick is moved to a central position. *British Aerospace*
Right: Some of the 'hi-tech' equipment vital to the ADV's mission. Upper left is the pilot's EHDD; upper right is the rear cockpit TV tab display (dual system); and the spread of systems below comprises (back row, left to right) SPILS computer, quadruplex actuator with CSAS control panel in front, CSAS pitch computer, AFDS computer, AFDS control panel and autothrottle actuator, and (front row) SPILS control panel, roll/yaw position transmitter, triplex rate gyro, pitch stick position transmitter and stick force transducer. *GEC Avionics*





SQUADRON SERVICE

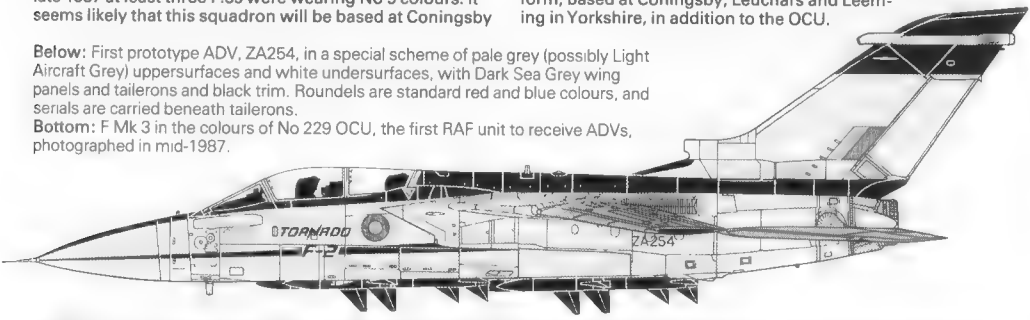
The ADV is only just beginning its front-line operational service with the Royal Air Force, so there are few hard facts concerning squadrons, locations and dates although general proposals have been officially outlined.

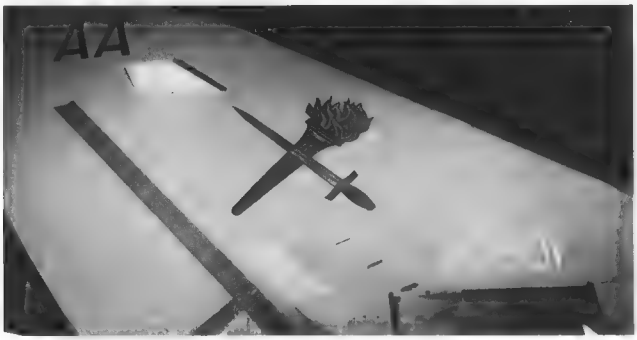
The first F Mk 2s were delivered to No 229 Operational Conversion Unit (OCU) at RAF Coningsby in Lincolnshire, which unit re-formed on 1 May 1985 although a number of ADVs had been on charge for some months prior to that. Conversion courses run by British Aerospace produced a 'core' of instructors, and training was gradually expanded during 1986, building up the OCU to its full capabilities as more aircraft were delivered from Warton. By early 1987 pilots and navigators – generally ex-Phantom crews – had begun to train for operational squadron service, and as F.3s began to arrive the strength of No 29 Squadron, the first front-line ADV unit and also based at Coningsby, began to be built up. No 29 was declared to NATO in November 1987, by which time the OCU had been designated No 65 Squadron in a 'shadow' role. The second operational front-line squadron to form with Tornado ADVs is No 5, previously flying Lightnings at Binbrook some 22 miles to the north of Coningsby, and by late 1987 at least three F.3s were wearing No 5 colours. It seems likely that this squadron will be based at Coningsby alongside No 29 and the OCU, especially since Binbrook is scheduled to relinquish its front-line status and be kept open only on a 'care and maintenance' footing following the retirement of the Lightnings, and since space has been made available at Coningsby with the departure of the Phantom OCU to Scotland.

It is speculated that No 11 Squadron, the other front-line Lightning operator, will in due course re-equip with Tornados, along with the two Phantom FG.1 operators, Nos 43 and 111 Squadrons based at Leuchars in Fife, whose aircraft, many of which are ex-Royal Navy machines, are among the oldest Phantoms on the inventory. It has been suggested that Nos 56 and 74 Squadrons, based at Wattisham in Suffolk, may re-equip with Tornado ADVs. Though logical – these are the only other Phantom units at present based in Britain – it might be observed that although No 74 flies ex-US Navy F-4Js, the aircraft were virtually rebuilt for RAF service and thus have more up-to-date systems than the Spey-engined Phantoms; moreover, they are not reported to be suffering the fatigue problems that are apparently beginning to afflict the FG.1s and FGR.2s.

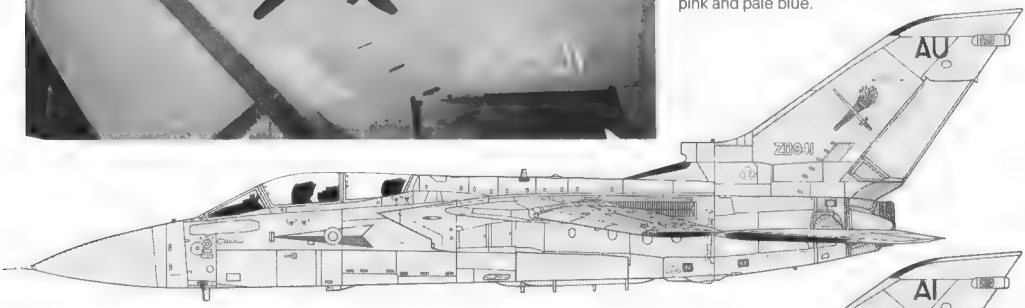
Seven squadrons of Tornado ADVs are scheduled to form, based at Coningsby, Leuchars and Leeming in Yorkshire, in addition to the OCU.

Below: First prototype ADV, ZA254, in a special scheme of pale grey (possibly Light Aircraft Grey) uppersurfaces and white undersurfaces, with Dark Sea Grey wing panels and tailerons and black trim. Roundels are standard red and blue colours, and serials are carried beneath tailerons.
Bottom: F Mk 3 in the colours of No 229 OCU, the first RAF unit to receive ADVs, photographed in mid-1987.

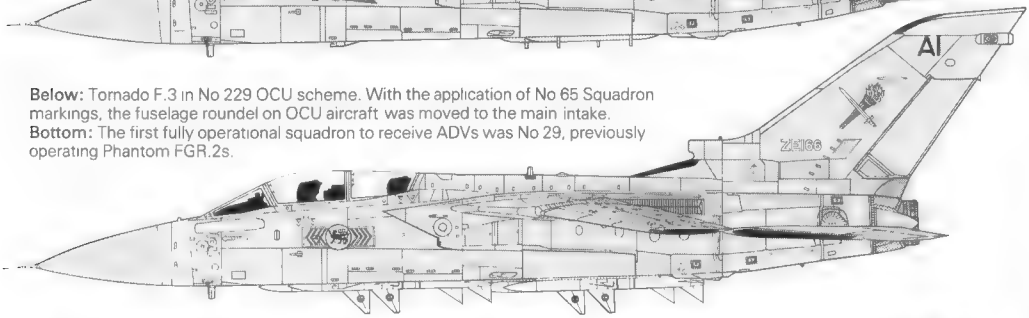




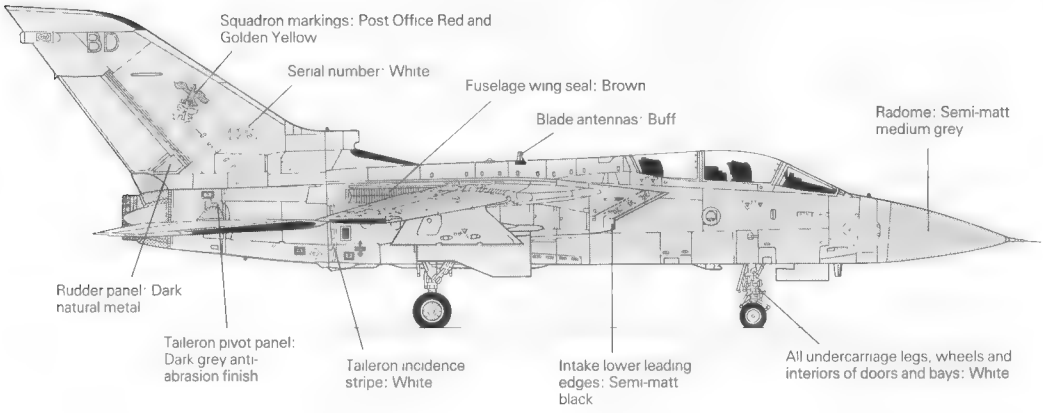
Left: Detail of No 229 OCU tail markings; torch and sword hilt are yellow with black outlining, flames are red and yellow, and blade is medium grey with black outlining.
Below: Tornado F.2 in early No 229 OCU markings, with red and yellow flash on forward fuselage; camouflage scheme is standard, as depicted on pages 34–35, and roundels and fin flash are in 'lo-viz' pink and pale blue.

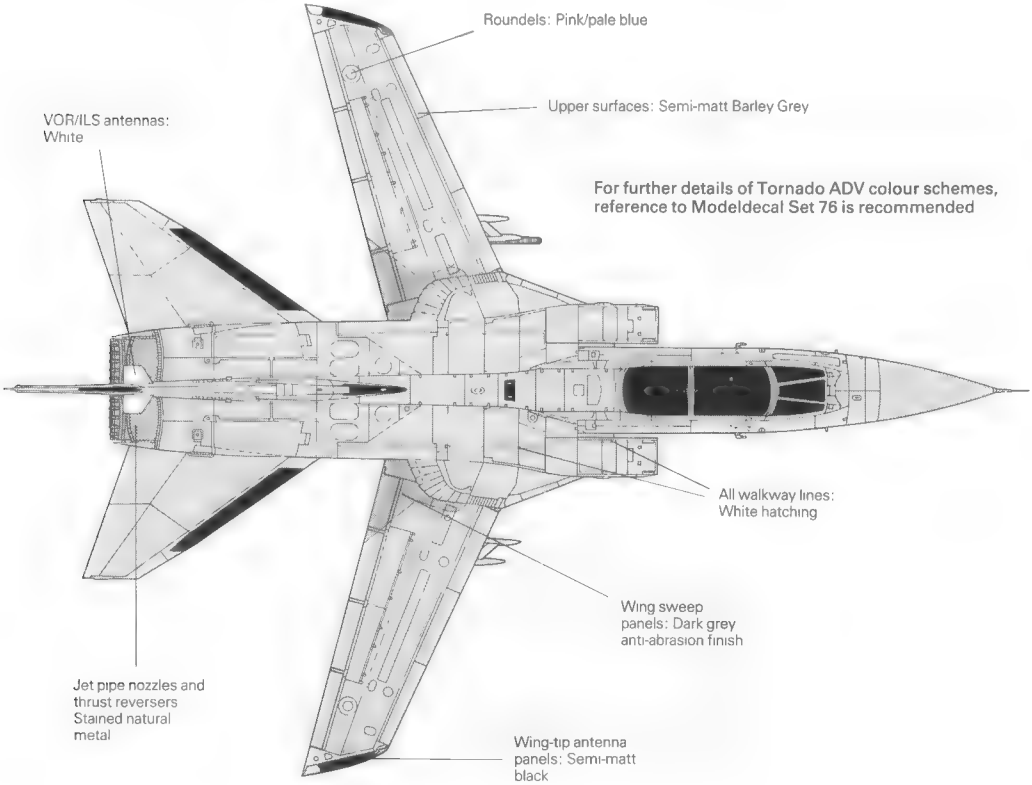


Below: Tornado F.3 in No 229 OCU scheme. With the application of No 65 Squadron markings, the fuselage roundel on OCU aircraft was moved to the main intake.
Bottom: The first fully operational squadron to receive ADVs was No 29, previously operating Phantom FGR.2s.



PANAVIA TORNADO F Mk 3, No 29(F) SQUADRON, RAF CONINGSBY, JULY 1987

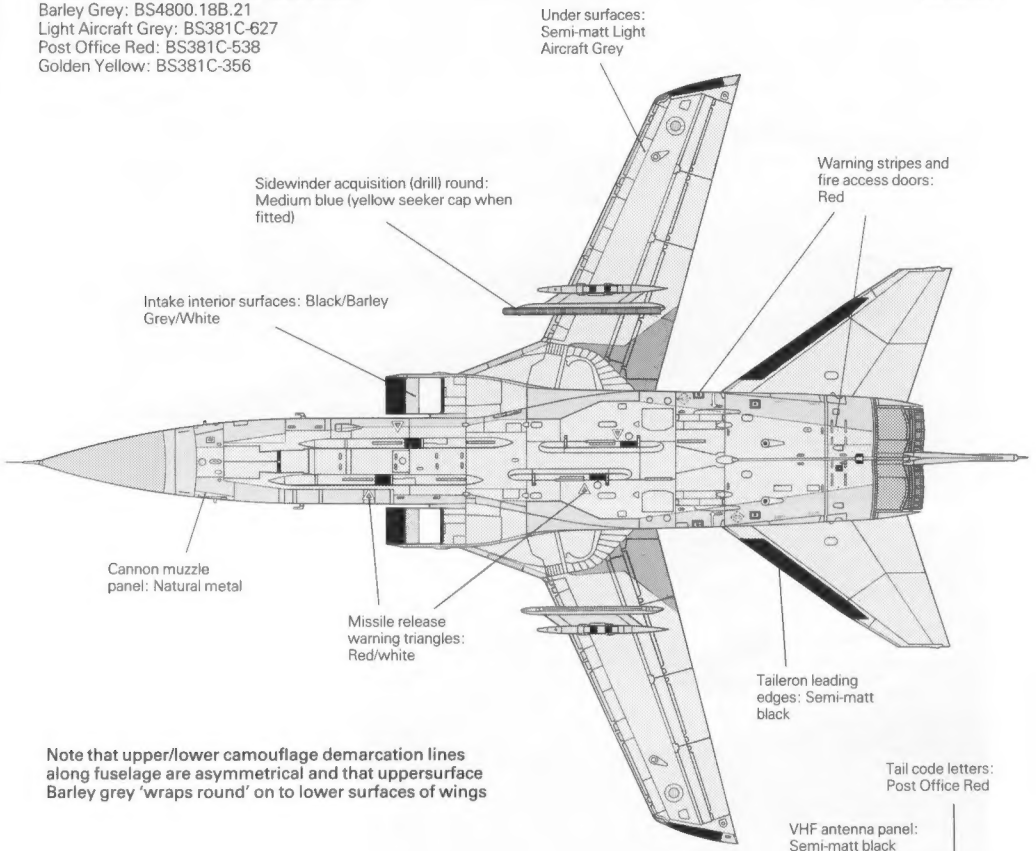




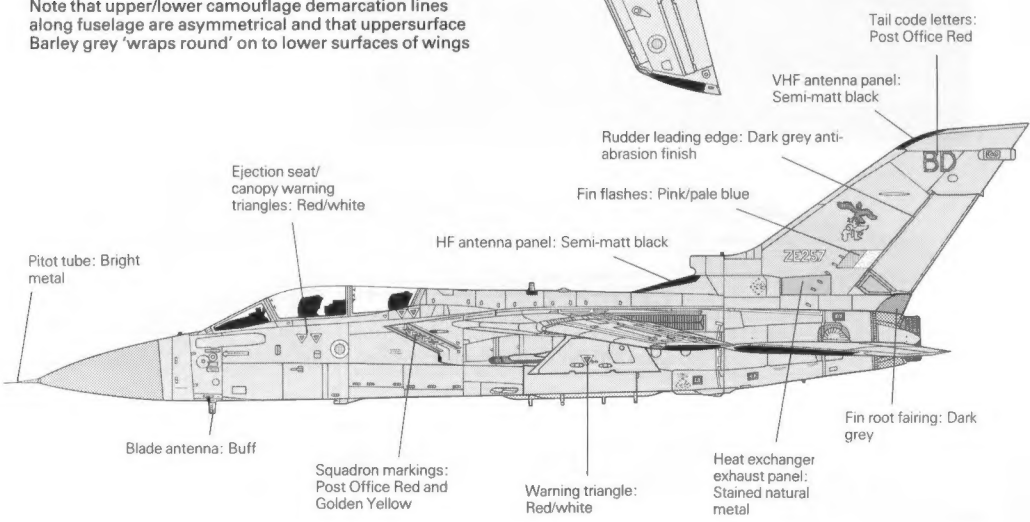
For further details of Tornado ADV colour schemes, reference to Modeldecal Set 76 is recommended

British Standard (BS) colour references:
Barley Grey: BS4800.18B.21
Light Aircraft Grey: BS381C-627
Post Office Red: BS381C-538
Golden Yellow: BS381C-356

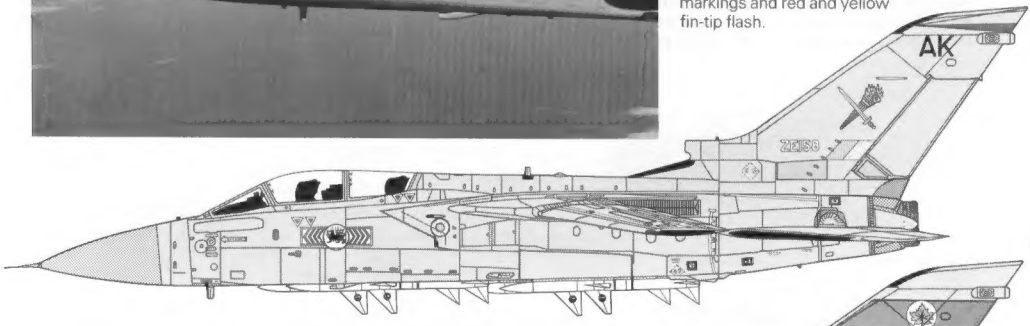
1:96 scale

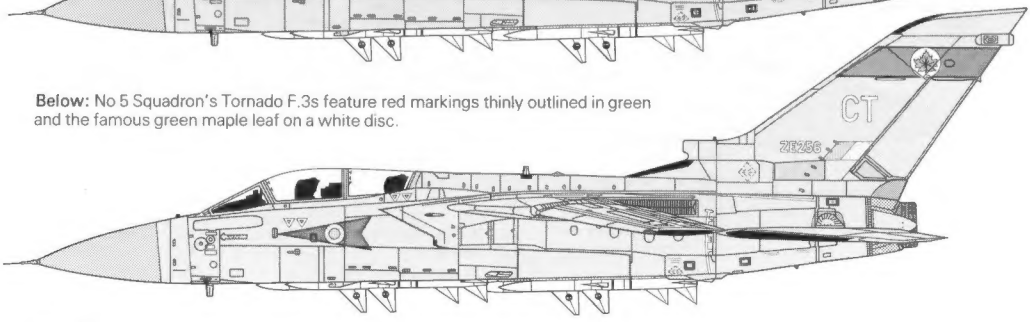


Note that upper/lower camouflage demarcation lines along fuselage are asymmetrical and that uppersurface Barley grey 'wraps round' on to lower surfaces of wings



Above: F Mk 3s began to appear in No 5 Squadron markings late in 1987 as the unit worked up. Here one of its first aircraft is shown in company with a Lightning, the Squadron's previous equipment. *Flt Lt Tony Paxton/No 5 Sqn*
Left: A No 229 OCU Tornado with No 65 'shadow' squadron markings takes on fuel from a dispensing tanker. *Sqn Ldr Andy Lister-Tomlinson via BAe*
Below: Another variation of the No 229 scheme, with 'shadow' squadron markings and red and yellow fin-tip flash.





Below: No 5 Squadron's Tornado F.3s feature red markings thinly outlined in green and the famous green maple leaf on a white disc.

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